

Temperature Control System and Method for Heating and Maintaining Medical Items at Desired Temperatures

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority from U.S. Provisional Patent Application Serial No. 60/104,635, entitled "Temperature Control System and Method for Heating and Maintaining Medical Items at Desired Temperatures", filed October 16, 1998, and from U.S. Provisional Patent Application Serial No. 60/126,651, entitled "Temperature Control System and Method for Heating and Maintaining Medical Items at Desired Temperatures in Various Locations", filed March 29, 1999. The disclosures of the above-mentioned provisional applications are incorporated herein by reference in their entireties.

BACKGROUND OF THE INVENTION

1. Technical Field:

The present invention pertains to systems for heating medical items. In particular, the present invention pertains to a system for heating and maintaining medical solution containers (e.g., bags or bottles containing saline or intravenous (IV) solutions, antibiotics or other drugs, blood, etc.) or other medical items (e.g., instruments, blankets, etc.) at desired temperatures.

2. Discussion of Related Art

Generally, various items are required to be heated prior to utilization in a medical procedure to prevent thermal shock and injury to a patient. These items typically include intravenous solution, surgical instruments, bottles and blankets. In order to provide the necessary heated items for use in medical procedures, medical personnel may utilize several types of warming systems to heat items toward their operational temperatures. For example, ovens may be disposed within operating rooms to heat items to desired temperatures. Further, U.S. Patent No. 4,495,402 (Burdick et al) discloses a warmer for heating wet dressings and other articles

1 disposed within a heating and storage compartment. The articles are arranged
2 within the compartment in stacked relation and disposed on a plate that is supplied
3 with thermal energy from a heater. The plate includes a center aperture whereby a
4 first thermal sensor is disposed in the aperture in contact with a bottommost article.
5 Control circuitry is disposed beneath the plate to control the heater to maintain
6 temperature of the bottommost article at a desired level based on the temperatures
7 sensed by the first thermal sensor and a second thermal sensor responsive to heater
8 temperature.

9 U.S. Patent No. 5,408,576 (Bishop) discloses an intravenous fluid warmer
10 having a cabinet structure to accommodate a plurality of intravenous fluid bags. A
11 temperature sensor and pad of heating filaments are disposed within the cabinet
12 structure, whereby the temperature sensor enables automatic temperature regulation
13 of the pad of heating filaments to heat the intravenous fluid bags. The heating
14 filaments are covered by a rubber layer to prevent melting of the bags during heating.
15 A temperature indicator disposed on the cabinet structure permits a user to ascertain
16 when a desired temperature is attained, whereby an intravenous fluid bag is removed
17 from the intravenous fluid warmer via an opening defined in a side of the cabinet
18 structure.

19 The warming systems described above suffer from several disadvantages.
20 In particular, ovens typically do not have a high degree of accuracy or control,
21 thereby enabling use of items having temperatures incompatible with a medical
22 procedure and possibly causing injury to a patient. Further, the Burdick et al and
23 Bishop warmers employ heaters that generally contact a particular portion of an
24 article being heated, thereby heating articles in an uneven manner and enabling
25 formation of hot spots. Moreover, the Burdick et al and Bishop warming systems
26 heat items simultaneously to only a single desired temperature, thereby being
27 incompatible for applications requiring various items to be heated to different
28 temperature ranges.

29 The present invention overcomes the aforementioned problems and provides
30 several advantages. For example, the present invention evenly distributes heat
31 among intravenous solution bags or other medical items contained within system
32 drawer sub-compartments, thereby avoiding creation of "hot spots" and "cold spots"

1 and ensuring relatively uniform heating of the entire bag with enhanced temperature
2 control. Further, each system drawer includes a window to enable viewing of the
3 intravenous solution bags or other medical items during heating, while the system
4 drawers facilitate easy access to the medical items within the system. In addition,
5 the present invention incurs low operating costs, while providing versatility since the
6 system drawers are each individually controlled to enable the system to heat
7 intravenous solution bags or various other medical items to the same or different
8 desired temperatures.

9

10 **OBJECTS AND SUMMARY OF THE INVENTION**

11 Accordingly, it is an object of the present invention to simultaneously maintain
12 various items at different desired temperatures for use in medical procedures.

13 It is another object of the present invention is to simultaneously maintain
14 various items at different desired temperatures for use in medical procedures via a
15 temperature control system including individually controlled drawers, whereby each
16 drawer is maintained at an associated desired temperature.

17 Yet another object of the present invention is to heat a medical item to a
18 desired temperature by uniformly distributing heat about the medical item, thereby
19 avoiding creation of "hot spots" and "cold spots".

20 Still another object of the present invention is to uniformly distribute heat
21 about a medical item within a system drawer sub-compartment by conducting heat
22 from a sub-compartment bottom wall along sub-compartment side walls.

23 A further object of the present invention is to mount a temperature control
24 system on a wall, intravenous (IV) pole, transportable cart or other support structure,
25 via a support mechanism, to enable heating of medical items at various locations.

26 Yet another object of the present invention is to mount a plurality of
27 temperature control systems in stacked or other relation on a transportable cart or
28 other support structure to enable heating of numerous medical items to desired
29 temperatures at various locations.

30 The aforesaid objects may be achieved individually and in combination, and
31 it is not intended that the present invention be construed as requiring two or more of
32 the objects to be combined unless expressly required by the claims attached hereto.

1 According to the present invention, a temperature control system includes a
2 cabinet or system housing having a plurality of drawers for containing intravenous
3 solution bags or other medical items. Each drawer is individually controlled, and
4 generally includes a window and a plurality of sub-compartments with each sub-
5 compartment accommodating an intravenous solution bag or other medical item.
6 The drawers are each pivotable relative to the system housing to permit access to
7 the sub-compartments, while the drawer windows enable the intravenous solution
8 bags to be viewed during heating. A heating element is typically disposed beneath
9 each drawer bottom wall to apply heat to walls of corresponding sub-compartments
10 and evenly distribute heat to intravenous solution bags contained within those sub-
11 compartments. Each drawer is associated with a controller that controls the heating
12 element to apply heat to the corresponding drawer sub-compartments in accordance
13 with a comparison between desired and measured temperatures associated with that
14 drawer. Alternatively, the system may include a single common controller to control
15 the heating element of each drawer based on the desired and measured
16 temperatures associated with that drawer. The temperature control system may be
17 mounted on a wall, intravenous (IV) pole, transportable cart or other suitable
18 structure via a support mechanism. In addition, several temperature control systems
19 may be mounted in a stacked or other arrangement on a transportable cart or other
20 structure to provide heating capability for numerous medical items.

21 The above and still further objects, features and advantages of the present
22 invention will become apparent upon consideration of the following detailed
23 description of specific embodiments thereof, particularly when taken in conjunction
24 with the accompanying drawings, wherein like reference numerals in the various
25 figures are utilized to designate like components.

BRIEF DESCRIPTION OF THE DRAWINGS

27 Fig. 1 is a view in perspective of a temperature control system in accordance
28 with the present invention.

29 Fig. 2 is an exploded perspective view of a drawer of the system of Fig. 1.

30 Fig. 3 is a view in elevation of an exemplary heating element of the system of
31 Fig. 1.

32 Fig. 4 is an electrical schematic diagram of an exemplary control circuit of the

1 system of Fig. 1.

2 Fig. 5 is a view in perspective of an alternative embodiment of the temperature
3 control system of Fig. 1 having a single controller.

4 Fig. 6 is an exploded view in perspective of a support mechanism for
5 mounting a temperature control system on a wall or other suitable structure
6 according to the present invention.

7 Fig. 7 is an exploded view in perspective of a temperature control system
8 mounted on an intravenous (IV) pole according to the present invention.

9 Fig. 8 is a side perspective view of plural temperature control systems
10 mounted on a transportable cart in accordance with the present invention.

11 Fig. 9 is a top view of the temperature control systems of Fig. 8 mounted on
12 the transportable cart.

13 Fig. 10 is a top view of a configuration for mounting four temperature control
14 systems on a transportable cart according to the present invention.

15 Fig. 11 is a view in perspective of an alternative configuration for mounting
16 four temperature control systems on a transportable cart according to the present
17 invention.

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19 **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

20 A temperature control system for heating and maintaining medical solution
21 containers (e.g., bags or bottles containing saline or intravenous (IV) solutions,
22 antibiotics or other drugs, blood, etc.) or other medical items (e.g., instruments,
23 blankets, etc.) at desired temperatures is illustrated in Figs. 1 - 2. Specifically,
24 temperature control system 2a includes a cabinet or system housing 4 having
25 substantially similar drawers 6a, 6b for enabling placement and removal of medical
26 items, such as intravenous solution bags, within the system and corresponding
27 controllers 22 for individually controlling heating of the drawers to maintain the bags
28 at the same or different desired temperatures. Cabinet 4 is generally in the form of
29 a rectangular box and includes top and bottom walls 10, 12, side walls 14, 16 and
30 front and rear walls 18, 20. The cabinet walls are each substantially rectangular and
31 collectively define a cabinet interior. Further, side wall 16 typically includes a series
32 of labels 24, such as fuse warning labels and labels providing other information, and

1 a plurality of fuse holders 26 for receiving fuses of the system control circuitry
2 described below. The cabinet is typically constructed of electro-galvanized steel
3 (e.g., eighteen gauge) or other suitably sturdy material, and includes, by way of
4 example only, a height of approximately twenty-five inches, a width of approximately
5 fifteen inches and a depth of approximately six inches. However, the cabinet may
6 be of any size or shape. It is to be understood that the terms "top", "bottom", "side",
7 "front", "rear", "horizontal", "vertical", "upper", "lower", "height", "length", "width",
8 "depth", "forward" and the like are used herein merely to describe points of reference
9 and do not limit the present invention to any specific orientation or configuration.

10 Drawers 6a, 6b are generally disposed in vertical alignment in front wall 18
11 toward side wall 14, while controllers 22 are each disposed in front wall 18 adjacent
12 a corresponding drawer 6a, 6b and power switch 23 toward side wall 16. Each
13 controller 22 enables entry of a desired or set point temperature associated with a
14 corresponding drawer and controls heating of intravenous solution bags residing
15 within the corresponding drawer based on the associated desired temperature as
16 described below. Each power switch 23 is generally disposed below a corresponding
17 controller 22 and enables power to that controller for heating intravenous solution
18 bags disposed within the corresponding drawer. By way of example only, cabinet 4
19 includes two each of drawers, associated power switches, controllers and
20 accompanying control circuitry, however, any quantity (e.g., at least one) of drawers,
21 power switches, controllers and control circuitry may be utilized, while the cabinet
22 components may be arranged in any fashion.

23 Drawers 6a, 6b each include a front wall or door 28, a rear wall 30, a bottom
24 wall 32 and side walls 34, 36. The drawer walls are each substantially rectangular
25 and collectively define a compartment or drawer interior having an open top portion
26 for enabling placement and removal of intravenous solution bags within the drawers.
27 By way of example only, the drawer rear, bottom and side walls define a drawer
28 including a height of approximately eight and one-half inches, a width of
29 approximately ten inches and a depth of approximately three and one-half inches.
30 However, the drawers may be of any size or shape, and the system may include any
31 combination of drawers of different or substantially similar types.

32 Door 28 includes a handle 38 typically disposed toward the door upper

1 portion, whereby the handle may be implemented by any conventional or other type
2 of handle. Alternatively, the handle may be disposed on the door at any suitable
3 location. Door 28 generally enables a corresponding drawer to pivot into and out of
4 the cabinet as described below, and is typically constructed of electro-galvanized
5 steel (e.g., sixteen gauge) or other suitably sturdy material. The door further includes
6 a substantially rectangular opening 40 covered by a substantially transparent
7 material 42, such as glass or plexiglass, to serve as a window to enable viewing of
8 the intravenous solution bags and maintain heat within the cabinet. By way of
9 example only, door 28 includes a height of approximately eleven and one-half
10 inches, and a width of approximately fourteen and one-half inches, however, the
11 door, opening and transparent material may be of any size or shape.

12 Divider walls 44, 46 are disposed within each drawer interior to partition that
13 interior into sub-compartments or bins 52a, 52b, 52c. In particular, divider walls 44,
14 46 extend from rear wall 30 substantially in parallel to, and include dimensions
15 substantially the same as, side walls 34, 36. The front and rear edges of dividers 44,
16 46 are bent at an angle of approximately ninety degrees relative to the respective
17 divider wall body portions, and extend transversely toward side wall 34 to form
18 ledges 48, 50, respectively. Similarly, the front edges of side walls 34, 36 are bent
19 at an angle of approximately ninety degrees relative to the respective side wall body
20 portions, and extend transversely toward each other to form ledges 49, 51,
21 respectively. Further, the front edge of bottom wall 32 is bent at an angle of
22 approximately ninety degrees relative to the bottom wall body portion, and extends
23 upward toward a drawer upper portion to form ledge 53. Ledges 50 enable the
24 divider walls to interface rear wall 30, while ledges 48 include a recess or gap to
25 permit the divider walls to engage and secure transparent material 42 within opening
26 40 of door 28. Moreover, ledges 48, 49, 51 and 53 enable the door to interface the
27 drawer side, bottom and divider walls. Each drawer sub-compartment is typically
28 configured to accommodate a single intravenous solution bag, and is defined by the
29 drawer rear, bottom, side and divider walls. Specifically, sub-compartment 52a is
30 defined between side wall 34 and divider wall 44, sub-compartment 52b is defined
31 between divider walls 44, 46 and sub-compartment 52c is defined between divider
32 wall 46 and side wall 36. The drawer side, rear, bottom and divider walls are typically

1 constructed of copper or other suitable heat conducting material to conduct and
2 evenly distribute heat to the intravenous solution bags disposed within the drawer as
3 described below.

4 A heating element or pad 54 is typically disposed on the underside of each
5 drawer bottom wall 32, whereby the heat applied by the heating pad is conducted by
6 the drawer bottom, side, rear and divider walls to provide an even heat distribution
7 to the intravenous solution bags residing in the sub-compartments of that drawer.
8 In other words, each individual drawer sub-compartment includes bottom, side and
9 rear walls that conduct and directly transmit heat from the heating pad to the
10 intravenous solution bag contained in that sub-compartment, thereby preventing
11 other intravenous solution bags residing in the cabinet from being affected by the
12 applied heat. The application of heat from the sub-compartment walls provides a
13 relatively uniform heat distribution and prevents the occurrence of certain intravenous
14 solution bags (e.g., bags disposed near the heat source) attaining higher
15 temperatures than the remaining bags (e.g., bags disposed at other locations within
16 the cabinet) as is typically present in common single heat source systems.
17 Alternatively, the heating pad may be disposed on the side or rear walls of each
18 drawer.

19 The heating pad is preferably configured to cover only a portion of a drawer
20 bottom wall, but may include any type of configuration (e.g., strips, bars, segments,
21 include various openings, etc.). A temperature sensor 56 is typically disposed on the
22 underside of each drawer bottom wall 32 generally within the confines of the
23 corresponding heating pad (e.g., the portion of the heating pad not covering the
24 drawer bottom wall). The temperature sensor is preferably implemented by a
25 conventional RTD temperature sensor and measures the temperature of the bottom
26 wall of the corresponding drawer. However, the temperature sensor may be
27 implemented by any conventional or other type of temperature sensor, and may be
28 disposed at any suitable location on or within a drawer. The temperature
29 measurement of sensor 56 is provided to the controller associated with the drawer
30 for control of the corresponding heating pad as described below.

31 An exemplary heating pad of the type employed by the temperature control
32 system is illustrated in Fig. 3. Specifically, heating pad 54 is substantially rectangular

1 and includes a substantially rectangular opening 58. By way of example only,
2 heating pad 54 includes a width or shorter dimension of approximately three inches
3 and length or longer dimension of approximately ten inches, while opening 58
4 includes a width of approximately one inch and a length of approximately eight
5 inches. A connector 60 is disposed along a heating pad shorter dimension edge to
6 facilitate connections for the heating pad. The heating pad is preferably
7 implemented by a conventional etched foil silicon rubber heater (e.g., 44 watts, 120
8 VAC) having an extra layer of silicon rubber on the adhesive side. The heating pad
9 further includes a pressure sensitive adhesive for attachment to a drawer bottom
10 wall. Temperature sensor 56 is typically disposed within opening 58 (Fig. 2) to
11 measure the temperature of a corresponding drawer bottom wall as described
12 above. The heating pad may be of any quantity (e.g., at least one), shape, or size,
13 and may include any configuration that covers the entirety or a portion of a
14 corresponding drawer bottom wall. In addition, the heating element or pad may be
15 implemented by any conventional or other type of heater or heating element (e.g.,
16 heating coils) to heat the drawers.

17 Referring back to Figs. 1 - 2, side walls 34, 36 of drawers 6a, 6b interface
18 respective doors 28 via posts 62 to secure the drawers to the doors. Each door 28
19 further includes a pivoting mechanism having a pivot hinge 63 (Fig. 8) and a locking
20 hinge 64 to enable a corresponding drawer to angle forward and pivot outward from
21 the cabinet interior into an open position. In particular, locking hinge 64 includes a
22 receptacle 66 disposed on a corresponding door 28, a curved track or slide 68 and
23 a pin or bolt disposed within the cabinet interior (not shown). Receptacle 66 is
24 disposed toward an intermediate portion of the corresponding door and extends from
25 that door interior surface toward the cabinet interior. The receptacle includes an
26 opening through which a pin or bolt 70 is inserted to connect a proximal end of slide
27 68 to the corresponding door.

28 Curved slide 68 typically extends from receptacle 66 of the corresponding
29 door into the cabinet interior and curves toward cabinet bottom wall 12. The slide
30 includes an opening 72 extending along the slide from the receptacle into the cabinet
31 interior, whereby an associated cabinet interior bolt is disposed within and through
32 the opening to enable the corresponding drawer to pivot out of and into the cabinet

1 interior to open and closed positions, respectively. The distal end of the slide, in
2 combination with the associated cabinet interior bolt, serves as a stop to limit pivoting
3 or the forward angle of the corresponding drawer. Locking hinge 64 may be disposed
4 adjacent either side wall 34, 36 of the corresponding drawer, or a door may include
5 dual pivoting mechanisms, whereby a mechanism is disposed adjacent each
6 corresponding drawer side wall. An operator typically grasps handle 38 of a
7 corresponding door and applies force to draw that handle forward, thereby forcing
8 slide 68 of that door forward, while the associated cabinet interior bolt traverses
9 corresponding slide opening 72. When sufficient force is applied to the handle, the
10 distal end of the corresponding slide opening is caused to engage the associated
11 cabinet interior bolt to prevent further pivoting of a corresponding drawer.
12 Conversely, force may be applied to the handle to facilitate pivoting of the
13 corresponding drawer toward the cabinet to a closed position, whereby the
14 corresponding slide is forced into the cabinet interior, while the associated cabinet
15 interior bolt traverses corresponding slide opening 72.

16 Controllers 22 each typically include a display 74 (e.g., LED or LCD) and a
17 plurality of input devices or buttons 76 for enabling entry of a desired or set point
18 temperature for a corresponding drawer. Input devices 76 are manipulated to enable
19 entry of the desired temperature, while each display 74 may alternatively indicate the
20 actual temperature measured by a corresponding temperature sensor 56 (Fig. 2) or
21 the desired or set point temperature entered by the operator. Display 74 typically
22 displays the measured temperature, and may be directed, via the input devices, to
23 display the set point temperature.

24 The controllers each essentially implement a feedback control loop to control
25 heating of the corresponding drawers. Specifically, each controller 22 receives a
26 temperature signal from a corresponding temperature sensor 56 indicating the
27 temperature of the corresponding drawer bottom wall. In response to the measured
28 temperature of a corresponding drawer bottom wall being equal to or exceeding the
29 desired temperature associated with that drawer, the corresponding controller
30 disables power to the associated heating element via a solid state relay described
31 below. Conversely, when the measured temperature of the corresponding drawer
32 bottom wall is below the desired temperature associated with that drawer, the

1 corresponding controller enables power to the associated heating element via the
2 solid state relay. Each controller is preferably implemented by a Eurotherm Controls
3 Model 2132 Controller that is generally pre-programmed with a PID (Proportional-
4 Integral-Derivative) control algorithm to control the corresponding heating element
5 based on the measured temperature of the corresponding drawer. However, the
6 controllers may be implemented by any conventional or other processor or circuitry
7 utilizing any control algorithm to control the heating elements.

8 An exemplary control circuit of the temperature control system is illustrated in
9 Fig. 4. Specifically, system control circuit 77 includes control circuits 78a, 78b to
10 control heating of corresponding drawers 6a, 6b, respectively. The control circuits
11 are disposed between power conductors 80, 82 to enable power to the circuits.
12 Conductor 80 typically supplies a positive potential, while conductor 82 provides a
13 negative or reference potential. A fuse 84, preferably a conventional three Amp fuse,
14 is connected in series with conductor 80 and the control circuits to prevent surges
15 from damaging the circuitry. Control circuit 78a includes conventional power switch
16 23, controller 22, temperature sensor 56, a conventional solid state relay 88, a
17 conventional temperature cut out switch 92, heating element or pad 54 and
18 conventional fuses 86, 90. In particular, power switch 23 is connected to conductor
19 80, while fuse 86, typically a two Amp fuse, is connected between the power switch
20 and conductor 80 to prevent damage to the power switch. The power switch is
21 further connected to conductor 82 and controller 22 to enable power to the controller.

22 Controller 22 receives power from power switch 23 and is further connected
23 to temperature sensor 56, solid state relay 88 and heating pad 54. The temperature
24 sensor measures a corresponding drawer bottom wall temperature and transmits a
25 signal to controller 22 indicating that temperature. The controller controls solid state
26 relay 88 to enable or disable power to heating pad 54 based on the measured
27 temperature as described above. The solid state relay is connected to conductor 80
28 and heating pad 54, while fuse 90, typically a 0.5 Amp fuse, is connected between
29 the relay and conductor 80 to prevent damage to the relay. Moreover, temperature
30 cut-out switch 92 is connected between the relay and heating pad to disable the
31 heating pad in response to detecting a heating pad temperature in excess of a
32 predetermined threshold. Control circuit 78a may be implemented by any

1 conventional circuitry components performing the above-described functions.
2 Control circuit 78b is connected in parallel with and is substantially similar to control
3 circuit 78a described above to control heating of drawer 6b.

4 Operation of the temperature control system is described with reference to
5 Figs. 1 - 4. Initially, an operator selects intravenous solution bags (e.g., containing
6 intravenous solution) or other medical items for heating within the cabinet and
7 determines appropriate temperatures for the items. The operator subsequently
8 selects a drawer 6a, 6b and enables a corresponding power switch 23, whereby the
9 operator grasps and applies force to handle 38 of the selected drawer to pivot that
10 drawer outward from the cabinet interior to an open position. Intravenous solution
11 bags are disposed within any quantity (e.g., at least one) or combination of
12 corresponding drawer sub-compartments 52a, 52b, 52c such that any one sub-
13 compartment contains a single intravenous solution bag. The selected drawer is
14 subsequently pivoted into the cabinet interior to a closed position. The desired
15 temperature is entered into corresponding controller 22 via input devices or buttons
16 76. The controller receives signals from corresponding temperature sensor 56 (Fig.
17 2) and determines appropriate controls for solid state relay 88 (Fig. 4) to enable or
18 disable power to associated heating pad 54 as described above. The heating pad
19 applies heat to the corresponding drawer bottom wall, whereby the drawer rear, side
20 and divider walls conduct heat from the bottom wall to evenly distribute heat to the
21 intravenous solution bags residing within the corresponding drawer sub-
22 compartments as described above.

23 Controller 22 displays on display 74 the corresponding drawer bottom wall
24 temperature measured by temperature sensor 56, and may be directed to
25 alternatively display the desired temperature based on manipulation of input devices
26 76. Further, the intravenous solution bags may be viewed through transparent
27 material 42 during heating. When the intravenous solution bags have attained the
28 desired temperature, the selected drawer is pivoted to an open position as described
29 above, whereby the heated bags are removed from sub-compartments of the
30 selected drawer for use, while that drawer is subsequently returned to a closed
31 position. Further, additional intravenous solution bags may replace the removed
32 heated bags within those sub-compartments for heating by the system. It is to be

1 understood that either or both of the drawers may be used and independently
2 controlled in substantially the same manner described above to maintain items at the
3 same or different desired temperatures. Further, any quantity of intravenous solution
4 bags or items may be disposed within the sub-compartments and drawers for heating
5 by the cabinet.

6 Alternatively, the system may include a single common controller to provide
7 independent control of each drawer as illustrated in Fig. 5. System 2b is
8 substantially similar to system 2a described above except that system 2b includes
9 a single controller 29 for controlling each drawer and a common power switch 27 to
10 enable power to the system. Controller 29 and power switch 27 are typically
11 disposed on front wall 18 adjacent drawer 6a, but may be disposed at any suitable
12 locations on the cabinet. The common power switch is substantially similar to power
13 switches 23 described above, while controller 29 typically includes a display 74 (e.g.,
14 LED or LCD) and a plurality of input devices or buttons 76 for enabling entry of
15 desired or set point temperatures for the corresponding drawers. The input devices
16 are manipulated to enable entry of the desired temperatures, while display 74 may
17 indicate the actual temperature of each drawer bottom wall measured by a
18 corresponding temperature sensor 56 (Fig. 2) or the desired or set point
19 temperatures entered by the operator. Display 74 typically displays the measured
20 temperature of each drawer, and may be directed, via the input devices, to display
21 the set point temperatures.

22 Controller 29 provides independent control for each drawer and essentially
23 implements a feedback control loop to control heating of those drawers. Specifically,
24 controller 29 includes inputs for receiving temperature signals from temperature
25 sensor 56 of each drawer indicating the temperature of a corresponding drawer
26 bottom wall. In response to the measured temperature of a drawer bottom wall being
27 equal to or exceeding the desired temperature entered for a corresponding drawer,
28 the controller disables power to the heating element associated with that drawer via
29 a solid state relay as described below. Conversely, when the measured temperature
30 of the drawer bottom wall is below the desired temperature entered for the
31 corresponding drawer, the controller enables power to the heating element
32 associated with that drawer via the solid state relay. The controller is generally pre-

1 programmed with a fuzzy logic or other type of control algorithm to control each
2 drawer based on the measured temperature of the corresponding drawer bottom
3 wall.

4 Controller 29 is preferably implemented by a 32A Series
5 Temperature/Process Controller manufactured by Love Controls, a Division of Dwyer
6 Instruments, Inc. Generally, this type of controller provides single set point capability
7 for a process, or dual set point capability (e.g., dependent high and low set points)
8 for the same process, and displays the set point and actual or process temperatures.
9 However, in order to employ this type of controller within the present invention, the
10 32A Series Controller has been slightly modified. In particular, the alarm relay and
11 associated circuits of the 32A Series Controller have been removed to permit
12 insertion of loop circuitry, thereby enabling independent operation of plural set points.
13 Further, the 32A Series Controller has been modified to display the actual
14 temperature of each drawer bottom wall, while the set point temperatures entered
15 for the drawers may be displayed by manipulating input devices 76. In addition, the
16 options typically available for the 32A Series Controller have not been enabled. It
17 is to be understood that the controllers of the present invention may each be
18 implemented by any quantity of conventional or other processors or circuitry utilizing
19 any control algorithm to control the drawers, whereby the processors or circuitry may
20 accommodate any quantity of heaters, drawers or set points.

21 An exemplary control circuit for system 2b is substantially similar to the circuit
22 described above for Fig. 4 except that power switches 23 and associated fuses 86
23 are replaced by a single common power switch 27 (Fig. 5) and an associated fuse,
24 and controllers 22 are replaced by a single controller 29. Specifically, power switch
25 27 enables power to each drawer and the controller from power conductors 80, 82
26 (Fig. 4) in substantially the same manner described above for power switches 23.
27 A fuse, similar to fuse 86 described above, is connected between the positive
28 potential power conductor and power switch 27 to prevent damage to the power
29 switch. Controller 29 is connected to power switch 27 and the temperature sensor,
30 heater, and solid state relay associated with each drawer. The controller receives
31 temperature signals from the temperature sensor of each drawer and controls the
32 heating element associated with that drawer, via a corresponding solid state relay,

1 in substantially the same manner described above based on the measured
2 temperature of the corresponding drawer.

3 The temperature control systems described above may be mounted on a wall
4 or various other structures via a support mechanism as illustrated in Fig. 6.
5 Specifically, a support mechanism 180 includes a base 182 and an engagement
6 member 184. Base 182 is substantially rectangular and includes a series of holes
7 186 (e.g., preferably four) arranged in a box-like configuration, whereby a hole 186
8 is defined in the base toward the upper and lower portions of each base side edge.
9 The holes receive bolts or screws 187 to mount the support mechanism on a wall
10 188 or other structure. Engagement member 184 is typically formed integral with
11 and extends forwardly from the base. In the preferred embodiment, engagement
12 member 184 has a generally rectangular configuration with truncated upper corners
13 and an arcuate lower portion 185 by which member 184 is joined to the base. In
14 particular, the arcuate lower portion extends slightly downward from the base bottom
15 edge and subsequently curves to an upward direction to enable the engagement
16 member upper portion to be spaced from the base by a slight distance and to extend
17 from the curved lower portion substantially parallel to the base. The engagement
18 member dimensions are preferably less than the base dimensions such that the
19 engagement member partially overlies the base central portion residing between
20 holes 186 defined toward the base side edges. The engagement member, in
21 combination with the base, essentially forms a hook – type device for engaging a
22 temperature control system.

23 A bracket 124 is disposed on a temperature control system 2a, 2b to interface
24 support mechanism 180. In particular, bracket 124 includes a base 130, exposed
25 wall 132, top wall 134 and side walls 136, 138. Base 130 is preferably welded or
26 otherwise secured to a temperature control system 2a, 2b toward the intermediate
27 portion of cabinet rear wall 20, while exposed wall 132 projects substantially parallel
28 to and is separated by a slight distance from the bracket base. The bracket base
29 dimensions are preferably greater than the dimensions of the exposed wall such that
30 the exposed wall generally covers the bracket base upper portion. The bracket top
31 and side walls interconnect the bracket base and exposed wall, thereby forming a
32 bracket compartment having an open bottom portion. The bracket compartment

1 dimensions are slightly greater than the dimensions of engagement member 184
2 such that the engagement member upper portion is received within the bracket
3 compartment. Temperature control system 2a, 2b may be placed on wall 188,
4 whereby engagement member 184 is inserted into the bracket compartment to
5 suspend that temperature control system from the wall. Medical items, such as
6 intravenous solution bags, may subsequently be heated within temperature control
7 system 2a, 2b as described above.

8 Temperature control systems 2a, 2b may be further mounted on an
9 intravenous (IV) pole as illustrated in Fig. 7. Specifically, support mechanism 180
10 may be attached to an intravenous (IV) pole 100 via a support frame 102 to enable
11 temperature control system 2a, 2b to be suspended from that pole. The support
12 frame includes a base plate 104 and a mounting plate 106. The base and mounting
13 plates are each substantially rectangular and include respective arcuate channels
14 126, 128 defined in the respective interior plate surfaces for interfacing pole 100.
15 Mounting plate 106 includes a series of holes 108 (e.g., preferably four) arranged in
16 a box-like configuration, whereby a hole 108 is defined in the mounting plate toward
17 the upper and lower portions of each mounting plate side edge. Support mechanism
18 180 is positioned adjacent mounting plate 106 with support mechanism holes 186
19 disposed coincident mounting plate holes 108. Threaded bolts 112 (e.g., preferably
20 four) are inserted through corresponding mounting plate and support mechanism
21 holes 108, 186 while a plurality of washers 118 (e.g., preferably four) are disposed
22 on a corresponding bolt 112 proximate the mounting plate interior surface. A series
23 of substantially annular nuts 120 (e.g., preferably four) are internally threaded to
24 engage the threads of respective bolts 112. Nuts 120 each engage a corresponding
25 bolt 112 to secure the support mechanism to mounting plate 106.

26 Base plate 104 has a height similar to, and a width less than the
27 corresponding dimensions of mounting plate 106, and has a series of holes 116
28 (e.g., preferably four) arranged in a box-like configuration, whereby a hole 116 is
29 defined in the base plate toward the upper and lower portions of each base plate
30 side edge. Holes 116 enable base plate 104 to be secured to mounting plate 106,
31 whereby the mounting plate further includes a set of corresponding holes 110 (e.g.,
32 preferably four). Holes 110 are similarly arranged in a box-like configuration,

1 whereby a hole 110 is defined in the mounting plate toward the portions residing
2 between each hole 108 and channel 128. Holes 110 are each internally threaded
3 for engaging fastening devices, such as screws or bolts. Base and mounting plates
4 104, 106 are placed about pole 100 such that the pole is positioned between the
5 plates and within plate channels 126, 128, while holes 116 of base plate 104 are
6 disposed coincident holes 110 of mounting plate 106. Threaded bolts 114 (e.g.,
7 preferably four) are inserted through corresponding washers 122 (e.g., preferably
8 four) and associated base and mounting plate holes 116, 110. Bolts 114 each are
9 threaded to engage the threads of holes 110, whereby the bolts secure base plate
10 104 to mounting plate 106. The interconnected base and mounting plates engage
11 pole 100, thereby securing support mechanism 180 to the pole and enabling the
12 support mechanism to suspend temperature control system 2a, 2b via bracket 124
13 as described above.

14 The temperature control systems described above may be further configured
15 to be transportable as illustrated, by way of example only, in Figs. 8 - 9. Specifically,
16 a pair of temperature control systems may be disposed on a cart 94 or other
17 transportable device to enable the systems to be transportable. Each member of the
18 system pair may be implemented by any of the temperature control systems 2a, 2b
19 described above. Cart 94 typically includes a substantially rectangular platform 96
20 having wheels or casters 98 (e.g., preferably four) attached thereto. A supporting
21 structure 99 is disposed toward the middle of the platform and is generally in the
22 form of a substantially rectangular beam having a height similar to, and a width
23 substantially less than, the corresponding dimensions of the temperature control
24 systems. Support mechanisms 180 are attached to the wider dimensioned
25 supporting structure walls to suspend corresponding temperature control systems
26 from the supporting structure. The temperature control systems are typically
27 disposed on the cart with respective cabinet rear walls 20 in facing relation to enable
28 brackets 124 to interface the support mechanisms attached to supporting structure
29 99. The support mechanisms may be attached to, and suspend temperature control
30 systems from, the supporting structure in substantially the same manner described
31 above for Fig. 6. The temperature control systems function in substantially the same
32 manner described above, whereby the temperature control systems may heat

1 various medical items and be transportable, via the cart, to various locations.

2 An alternative configuration for disposing four temperature control systems on
3 transportable cart 94 is illustrated in Fig. 10. Specifically, supporting structure 99 is
4 disposed toward a middle portion of platform 96 and is generally in the form of a
5 substantially rectangular beam having height and width dimensions similar to the
6 corresponding dimensions of the temperature control systems. Each temperature
7 control system may be implemented by any of the temperature control systems 2a,
8 2b described above. A support mechanism 180 (Fig. 6) is attached to each of the
9 vertically extending supporting structure walls. Temperature control systems 2a, 2b
10 are positioned such that brackets 124 interface a corresponding support mechanism
11 180 to suspend the temperature control systems from the supporting structure. The
12 support mechanisms may be attached to, and suspend the temperature control
13 systems from, the supporting structure in substantially the same manner described
14 above for Fig. 6. The temperature control systems function in substantially the same
15 manner described above, whereby the temperature control systems may heat
16 various medical items and be transportable, via the cart, to various locations.

17 The temperature control systems described above may further be arranged
18 in stacked relation on transportable cart 94 as illustrated in Fig. 11. Specifically,
19 supporting structure 99 is disposed toward a middle portion of platform 96 and may
20 include a plurality of stacked supporting structure units each in the form of a
21 substantially rectangular beam and having height and width dimensions similar to the
22 corresponding dimensions of the temperature control systems. Alternatively, the
23 supporting structure may be implemented by an integral unit in the form of an
24 elongated substantially rectangular beam having a width dimension similar to the
25 width dimension of the temperature control systems, but a varying height dimension
26 similar to the combined height dimensions of a plurality of temperature control
27 systems to facilitate a stacked temperature control system arrangement. Each
28 temperature control system may be implemented by any of the temperature control
29 systems 2a, 2b described above. The supporting structure is configured in the form
30 of a tower having a plurality of vertically arranged levels with each level including
31 support mechanisms 180 attached to the vertically extending walls of the supporting
32 structure to suspend temperature control systems 2a, 2b. The support mechanisms

1 may be attached to, and suspend temperature control systems from, the supporting
2 structure at each level in substantially the same manner described above for Fig. 6.

3 The tower configuration may be basically formed by a plurality of the above-
4 described configurations arranged one atop the other. By way of example only, the
5 tower configuration illustrated in Fig. 11 is generally constructed of a plurality of the
6 configurations described above for Figs. 8 - 9, and includes two levels each having
7 two temperature control systems. However, the tower configuration may include any
8 quantity of levels with each level having any quantity of associated temperature
9 control systems arranged in any configuration. The temperature control systems
10 may be implemented by any of the temperature control systems described above,
11 and may heat various medical items and be transportable, via the cart, to various
12 locations. Alternatively, the above-described temperature control system
13 configurations for the transportable cart may be implemented on any suitable
14 stationary or mobile structure.

15 The temperature control system configurations described above may further
16 include an intravenous pole and/or other equipment disposed on a temperature
17 control system, supporting structure or transportable device. Further, the pole and/or
18 equipment may include any quantity of temperature control systems attached to the
19 pole and/or equipment, and may be disposed on the transportable device to suspend
20 the temperature control systems with or without the use of the supporting structure.
21 Moreover, the supporting structure may include a plurality of supporting structure
22 units arranged in various configurations (e.g., arranged in a triangular, circular or
23 polygonal fashion) or be of any cross-sectional shape, and include corresponding
24 supporting mechanisms to suspend various quantities of temperature control
25 systems. In addition, the configurations described above may be arranged in
26 stacked relation in any fashion (e.g., a circular supporting structure or structure
27 arrangement may be stacked with a triangular or polygonal supporting structure or
28 structure arrangement, etc.).

29 It will be appreciated that the embodiments described above and illustrated
30 in the drawings represent only a few of the many ways of implementing a
31 temperature control system and method for heating and maintaining medical items
32 at desired temperatures.

1 The temperature control systems and components may be of any size or
2 shape and may be constructed of any suitable materials. The controllers, fuses,
3 power switches and labels may be disposed on the systems at any suitable
4 locations. The systems may include any quantity of each component, while the
5 components (e.g., cabinet, circuitry, drawers, etc.) may be arranged in any fashion.
6 The temperature control systems may include any quantity (e.g., at least one) of
7 drawers with each drawer having any quantity (e.g., at least one) of sub-
8 compartments. The drawers may be of any size or shape and may be constructed
9 of any suitable materials. The drawers may include any conventional or other handle
10 disposed at any location, and may include any conventional or other pivoting or
11 sliding mechanisms to facilitate placement and removal of drawers and items within
12 the systems. The drawer sub-compartments may be of any quantity, size or shape,
13 while the drawers and sub-compartments may each contain any quantity of any
14 types of medical items. The drawers may include a window of any shape or size, or
15 be implemented without a window. The window may include any type of transparent
16 or translucent material, and may be defined at any suitable locations on the drawer,
17 door or cabinet. Further, the drawers may be implemented by any types of drawers
18 that are capable of being placed and removed within the system (e.g., substantially
19 horizontal drawers, such as those in common desks), while the system may include
20 any quantity or combination of different types of drawers. Moreover, the drawers,
21 sub-compartments or other receptacles may be disposed within the cabinet interior
22 chambers on shelves or other structures for receiving the medical items.

23 The temperature sensor may be implemented by any conventional resistive
24 or other type of temperature sensing device, and may be disposed at any location
25 on the drawer or cabinet interior. The heating element may include any type of
26 configuration covering the entirety or a portion of the drawer bottom wall (e.g., strips,
27 bars, segments, include various openings, etc.). The heating element may be
28 implemented by any quantity of conventional or other types of heating devices (e.g.,
29 heating coils, etc.), and may be disposed on the drawer at any locations. The
30 heating element may include any type of conventional or other connector to facilitate
31 heating element connections, and may be fastened to the drawer via any
32 conventional or other fastening techniques (e.g., adhesives, brackets, etc.).

1 The control circuitry may be implemented by any quantity of conventional or
2 other circuit components capable of performing the above-described functions. The
3 relay may be implemented by any conventional solid state or other type of relay
4 device. Similarly, the cut-out switch may be implemented by any conventional or
5 other type of switching or power limiting device. The fuses may be implemented by
6 any conventional or other types of cut-off or switching devices, while the power
7 switches may be implemented by any conventional or other switching devices (e.g.,
8 momentary, button, etc.) The system may include any quantity of controllers, each
9 controlling any quantity of drawers and accommodating any quantity of set points.
10 The controllers may each be implemented by any conventional or other processor
11 or circuitry to control the heating elements.

12 The support mechanism may be of any shape or size, and may be
13 constructed of any suitably sturdy materials. The support mechanism may include
14 any configuration suitable to interface a member disposed at any location on a
15 temperature control system, or suitable to interface a temperature control system
16 directly. The support mechanism may further be connected to any structure via any
17 conventional or other fastening techniques, and may be configured to accommodate
18 any quantity of temperature control systems. The support mechanism base may be
19 of any shape or size, may be constructed of any suitable materials, may include any
20 quantity of holes of any shape or size defined at any location, and may utilize any
21 quantity and type of fastener of any shape or size to mount the support mechanism
22 on a structure. The engagement member may be integral with the base or be a
23 separate unit attached to the base via any conventional or other fastening
24 techniques. The engagement member may be of any shape or size, may be
25 constructed of any suitable materials and may be disposed in any fashion and at any
26 locations on the base.

27 The bracket may be of any shape or size, may be disposed at any suitable
28 locations on a temperature control system via any conventional or other fastening
29 techniques, and may be constructed of any suitably sturdy materials. The bracket
30 may include any type of configuration suitable to interface the support mechanism
31 or other support device. The support mechanism and bracket may be implemented
32 by any conventional or other securing or suspension devices, and may be utilized to

1 mount a temperature control system on any type of supporting structure.

2 The support frame plates may be of any shape or size, and may be
3 constructed of any suitable materials. The plates may be connected to any pole-type
4 or other structure of any cross-sectional shape via any conventional or other
5 fastening techniques. The plates may include any quantity of holes of any shape or
6 size defined at any location, and may utilize any quantity and type of fastener of any
7 shape or size (e.g., washers, nuts, bolts, etc.) to interconnect the plates and mount
8 the support mechanism on the support frame and pole or other structure. The plates
9 may include a groove or channel of any shape or size to interface any type of pole
10 or other structure. The grooves may be defined at any locations in one or more of
11 the plates, or the plates may be configured to surround or engage the pole or other
12 structure. The support frame may be implemented by any type of conventional or
13 other securing devices to mount a support device on the pole or other structure.

14 An intravenous pole and/or other equipment may be disposed at any locations
15 on the temperature control systems, supporting structure or transportable device.
16 The pole and/or equipment may include any quantity of temperature control systems
17 attached to the pole and/or equipment, and may be disposed on the transportable
18 device to suspend the temperature control systems with or without the use of the
19 supporting structure. The supporting structure may be of any size or shape, may be
20 constructed of any suitable materials and may be disposed at any locations on the
21 cart. The support structure may include a plurality of supporting structure units
22 arranged in various configurations (e.g., arranged in a triangular, circular or polygonal
23 fashion), be of any cross-sectional shape, and include any quantity of support
24 mechanisms or other devices at any locations to suspend various quantities of
25 temperature control systems.

26 The temperature control system configurations may include any quantity or
27 combination of the temperature control systems described above arranged in any
28 fashion. The temperature control system configurations described above may be
29 arranged in stacked relation in any fashion (e.g., a circular supporting structure or
30 structure arrangement may be stacked with a triangular or polygonal supporting
31 structure or structure arrangement, a two system configuration may be stacked with
32 a four system configuration, etc.).

1 The cart may be of any size or shape, may include any quantity of wheels or
2 other devices disposed at any locations on the cart enabling cart motion. The cart
3 may be implemented by any conventional or other type of transportable device.
4 Alternatively, the temperature control systems may include rollers, casters, wheels
5 or other rolling type structures disposed at any locations to enable the systems to be
6 transportable. In addition, the temperature control system configurations for the
7 transportable cart may be implemented on any suitable stationary or mobile
8 structure.

9 It is to be understood that the present invention is not limited to the specific
10 configurations or applications described above, but may be implemented by any
11 system including independently controlled chambers or compartments that evenly
12 distribute heat from a heat source to various types of medical or other items within
13 the compartments via the compartment walls. Further, the support mechanism of the
14 present invention may be utilized for mounting any system treating or handling
15 various types of medical items on any type of supporting structure.

16 From the foregoing description it will be appreciated that the invention makes
17 available a novel temperature control system and method for heating and
18 maintaining medical items at desired temperatures wherein medical items placed
19 within the system are uniformly heated to the same or different desired temperatures.

20 Having described preferred embodiments of a new and improved temperature
21 control system and method for heating and maintaining medical items at desired
22 temperatures, it is believed that other modifications, variations and changes will be
23 suggested to those skilled in the art in view of the teachings set forth herein. It is
24 therefore to be understood that all such variations, modifications and changes are
25 believed to fall within the scope of the present invention as defined by the appended
26 claims.